Mountain Meadow Improvement through Seeding

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Highlight: *Three mechanical methods were evaluated for control of the meadow weeds—sedge, cheatgrass, and poverty weed. Weed control and seedling stands were best on a summer fallow. Seeding in furrows aided seedling survival. A summer fallow-furrow technique was the weed control and seeding method used to evaluate grass and forb adaptability. Acceptable stands were more difficult to obtain in the cheatgrass-poverty weed type than in the sedge type. Seedling stands of Luna pubescent and Amur intermediate wheatgrasses were similar and were superior to those of Regar bromegrass, Alta tall fescue, and Primar slender wheatgrass. Production of pubescent wheatgrass was equal to or superior to that of intermediate wheatgrass. Bromegrass and fescue were not as productive as the introduced wheatgrasses. Native slender wheatgrass was as productive as the introduced wheatgrasses in a wet year but not in a dry year. Alfalfa and sainfoin stands averaged about one plant/3 ft of row. Herbage of these forbs was similar in quantity and quality to that in good sage grouse habitat.*

Mountain meadows occur adjacent to streams and seeps in mountainous topography in northern and central Nevada. Deep, fertile soils and good soil moisture relations from a water table contribute to a productive potential much greater and species composition much different from that on adjacent sagebrush (*Artemisia* spp.) range. Important tall-statured grasses are Nevada bluegrass (*Poa nevadensis*), slender wheatgrass (*Agropyron trachycaulum*), and meadow barley (*Hordeum brachyantherum*). Low growing grass and grass-like species include mat muhly (*Muhlenbergia richardsonis*), sedges (*Carex* spp.), and rushes (*Juncus* spp.). Important forbs are western yarrow (*Achillea lanulosa*), common dandelion (*Taraxacum officinale*), Rocky Mountain iris (*Iris missouriensis*), and pale agoseris (*Agoseris glauca*). These meadows are small (several hundred square feet to several hundred acres), yet the productive potential and species composition make them sources of livestock forage (Cornelius and Talbot, 1955) and the primary summer habitat for sage grouse (*Centrocercus urophasianus*) in Nevada (Savage et al., 1969; and Oakleaf, 1971).

Under season-long grazing and livestock concentration, meadows are sacrifice areas (Cornelius and Talbot, 1955). Many are not producing to potential for livestock or wildlife, nor is present cover protecting the site. Channel cutting, lowered water table, and a decrease of desirable native grasses and forbs have reduced productivity. Low quality meadow species have increased, and big sagebrush (*Artemisia tridentata*) and rabbitbrush (*Chrysothamnus* spp.) have invaded (Yoakum et al., 1969).

We described the present condition of mountain meadows in Nevada as follows: 1) fair to good condition with desirable species suppressed by improper livestock use. Grazing management will improve these areas. 2) Fair condition but with desirable species suppressed by iris. Improvement of these areas is the subject of another study. 3) Very poor condition with sedge or cheatgrass (*Bromus tectorum*) and poverty weed (*Iva axillaris*). This paper deals with improvement of these sites for livestock and wildlife by seeding.

Experimental Areas and Procedures

The study area was 8 miles north of Austin in central Nevada at 7,400 ft elevation. Precipitation from 1964 to 1971

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ranged from 8.1 to 33.2 inches and averaged 17.0 inches. Studies were made on the "upper" and "lower" sites in the meadow complex.

The upper site was a sheep bedground with residual vegetation of cheatgrass and poverty weed. The stream channel was approximately 5 ft deep. June minimum and August maximum water-table depths from 1965 to 1971 were 2.0 and 7.6 ft, respectively. The stream flowed most of the year, and a check dam impounded water and maintained a water table. Soil is a member of a fine, montmorillonitic, frigid family of Aquic Haploxerolls.

Vegetation on the lower site was dominated by sedge and suppressed cheatgrass with a few big sagebrush and rabbitbrush plants. The channel was 12 ft deep. Leakage under the check dam prevented water storage. The stream did not flow after July in most years. June minimum and August maximum water table depths were 3.5 and 18.8 ft, respectively. Soil is a member of a fine, montmorillonitic, frigid family of Cumulic Haploxerolls. Most studies were done here because this site is more characteristic of depleted meadows.

Seeding variables were year, site, weed control method, and species (Table 1). We used three weed control methods: 1) summer fallow—plow in June with a moldboard plow, 2) fall plow—plow in October before seeding, and 3) fall furrow—furrow with shovel -type openers before seeding. Furrowing removed competition from a band approximately 4 inches deep and 6 inches wide. A seedbed on plowed treatments was prepared with a disk-harrow. Results through 1967 indicated the superiority of the summer-fallow treatment for sedge control. Cornelius and Talbot (1955), Plummer et al. (1955), and Rummell and Holscher (1955) also found that weedy sod-type vegetation, as well as cheatgrass and poverty weed, could be controlled by a summer fallow. Success of seeding in furrows was demonstrated in the present study, in the cheatgrass-type (Eckert and Evans, 1967; and Evans et al., 1970), and on high elevation sites in Utah (Hull, 1970). Therefore, in 1968 the summer fallow-furrow technique was adopted as the best method for weed control and seedling establishment, and this technique was used in 1968 and 1969 studies. Furrows made after the seedbed had been disked were approximately 8 inches deep and 10 inches wide at the top.

Species seeded were Nordan crested (*Agropyron desertorum*), Amur intermediate (*A. intermedium*), Luna pubescent (*A. trichophorum*), and Primar slender (*A. trachycaulum*) wheatgrasses; Regar bromegrass (*Bromus biebersteinii*); and Alta tall fescue (*Festuca arundinaceae*). In all years, 24 pls/ft of row were fall-planted in 18-inch rows with three replications. In 1964, 20-ft single rows were seeded. In 1965, intermediate wheatgrass was seeded in five 20-ft rows. Eight rows, 50 to 100 ft long were seeded in 1968 and 1969. In these later years, Eski sainfoin (*Onobrychis viciaefolia*) and Ladak alfalfa (*Medicago sativa*) were seeded alone or in alternate rows with intermediate wheatgrass. These forbs were evaluated as possible substitutes for sage grouse food plants, such as dandelion and yarrow, not found on depleted meadows.

Weed control treatments were evaluated by weed yield and performance of seeded species. Species performance was evaluated by plant density (plants/ft of row—pfr), frequency (occupancy/ft of row—%), and height for 3 years after planting; and yield. The 1964 and 1965 seedings were not harvested because of small plot size and border effects. Yield was evaluated in 1970 and 1971 on the 1968 seeding and in 1971 on the 1969 seeding.

Water-table observation wells were dug to 20 ft, cased with perforated pipe, and backfilled with gravel.

Data were analyzed by analysis of variance, and treatment means were compared by Duncan's Multiple Range Test. Probability of 0.05 was accepted as significant except as noted.

Table 1. Seeding studies conducted from 1965 to 1969, including year, site, weed control method, and species.

Year	Site	Weed control treatment[1]			Species[2]
1964	Lower	SF	FP	FF	Agde, Agtra, Agin, Fear
1965	Lower	SF	FP	FF	Agin
1965	Upper	SF			Agin
1968	Lower	SF - Furrow			Agin, Agtr, Brbi, Fear, Mesa, Onvi
1968	Upper	SF - Furrow			Agin, Agtr, Agtra, Brbi Fear
1969	Lower	SF - Furrow			Agin, Agtr, Brbi, Fear, Mesa, Onvi

[1] SF = summer fallow; FP = fall plow; and FF = fall furrow. A check was included in 1964 and 1965.

[2] Agde = Nordan crested wheatgrass; Agin = Amur intermediate wheatgrass; Agtr = Luna pubescent wheatgrass; Agtra = Primar slender wheatgrass; Brbi = Regar bromegrass; Fear = Alta tall fescue; Mesa = Lakak alfalfa; Onvi = Eski sainfoin.

Table 2. Yield (lb/acre) of competitive vegetation the first and second years after seeding on four weed control treatments at the lower site.

Species and treatment	Yield of competitive species			
	First year		Second year	
Weed control treatments	Sedge	Cheatgrass	Sedge	Cheatgrass
Check	577a[1]	0a	701a	65a
Fall furrow	276b	208b	432b	0a
Fall plow	0c	828c	362b	62a
Summer fallow	0c	324b	281b	126a

[1] Species means within year followed by the same letter are not significantly different at the 0.1 probability level as determined by Duncan's Multiple Range Test.

Results and Discussion

Weed Control

Weed control treatments on the lower site resulted in significantly different kinds and amounts of competing vegetation in the first and second years after seeding (Table 2). Sedge was dominant on the check both years. Fall furrowing removed a strip of sedge adjacent to the seeded row. During the seedling year, sedge reinvaded the furrows and cheatgrass invaded the berms in about equal amounts. The net reduction in total competition was only 93 lb/acre. The following year, sedge reinvaded the furrows and berms, suppressed cheatgrass, and total competition was 269 lb/acre less than on the check.

Both plowing treatments controlled sedge for 1 year. The fall-plow treatment was made after cheatgrass had matured and seed was planted in tillage. All competition (828 lb/acre) in the seedling year was cheatgrass. The summer fallow killed most vegetative cheatgrass plants. However, escapes and residual seed resulted in a moderate cheatgrass stand (324 lb/acre) in the seedling year. The next year sedge had partially reinvaded both plowed treatments, suppressed cheatgrass, and competing vegetation was about half that on the check and about equal to that on the fall-furrow treatment.

A summer fallow resulted in kinds and amounts of weeds on the upper site different from those on the lower. Weed yield was 1,190 lb/acre of cheatgrass and 620 lb/acre of poverty weed, or a total of 1,810 lb/acre compared to 324 lb/acre of cheatgrass on the lower site.

Seeding Establishment

Seedling establishment of four species on three weed control treatments was evaluated for 3 years after seeding in 1964 (Table 3). Precipitation in these years was 8.1, 14.9, and 15.1 inches. Intermediate wheatgrass had the greatest density and frequency in each year. At the end of the third growing season, density and frequency were 2.4 pfr and 94%, respectively. The fescue stand was dense the year after seeding; however, frequency data show that this density was not uniformly distributed. By 1967, this stand had decreased to 0.8 pfr and 36%, similar to the crested wheatgrass stand. Density of slender wheatgrass decreased from 1.3 pfr in 1965 to 0.8 pfr in 1967. Frequency remained constant at 60 to 65%.

Seedling stands in the summer-fallow and fall-plow treatments were similar. Density decreased with time, and by 1966 and 1967 stands on the summer fallow were superior to those on the fall plow. Seedling stands in fall furrows were not as good as those in the two plow treatments; however, with time, density and frequency were maintained. Plant density and frequency in the summer-fallow and fall-furrow treatments were similar in 1966 and 1967. This was the first indication of the possible value of furrows for seedling survival on this high-potential site.

Results of the 1965 seeding also indicated the benefits of a summer fallow for weed control and furrows for plant survival. Results of the 1968 and 1969 seedings indicated the superiority of pubescent and intermediate wheatgrasses for seeding meadow sites.

Acceptable stands of pubescent and intermediate wheatgrasses were obtained on both the cheatgrass-poverty weed and sedge type (average of 2.0 and 3.2 pfr, respectively). However, acceptable stands of bromegrass, fescue, and slender wheatgrass were more difficult to obtain on the former (0.7 pfr) than on the latter (3.1) type. This is probably due to the greater amount of competitive vegetation on a summer fallow-furrow treatment of the former (1,810 lb/acre) in contrast to the latter (324 lb/acre) type.

Alfalfa and sainfoin stands averaged between one plant per 2.7 to 5.1 ft of row and 2.4 to 3.1 ft of row, respectively, whether seeded alone or in alternate rows. These stands were not harvested. However, a yield estimate of 50 to 80 lb/acre of sainfoin was based on the work of Ryerson and Taylor (1968) in Montana under dryland conditions. The alfalfa stand had similar productivity. Oakleaf (1971), calculated that a sage grouse population of 8 birds/acre (the highest density observed in a 4-year study) would consume about 10 lb/acre of forbs during the period of meadow use. The forage quality of alfalfa and sainfoin (Jensen et al., 1968) and dandelion and yarrow (Oakleaf, 1971) showed that crude protein, ether extract, and ash in succulent sage grouse food plants were equal to or slightly greater than that in seeded forbs. Crude fiber was about 9% less in meadow forbs. Quality of seeded forbs was determined on first-cut hay harvested in early July, when sage grouse normally occupy meadows.

Through the seeding techniques and species used, we established forbs that appear to satisfy the quantity and quality food requirements of sage grouse. Sage grouse preference for seeded forbs has been established (Patterson, 1952 and Harris, 1972[1]). Research is needed to determine longevity of these forbs in pure stands, in alternate rows with sodforming and bunch grasses, and under grazing.

Table 3. Density (plants/ft of row) and frequency (%) of four species averaged over four weed control treatments. Average density and frequency of seeded species on four weed control treatments. Seeded in fall, 1964.

	Density			Frequency		
	1965	1966	1967	1965	1966	1967
Species						
Intermediate wheatgrass	4.7a[1]	2.3a	2.4a	90a	81a	94a
Tall fescue	3.3b	0.9b	0.8b	60b	45b	36c
Slender wheatgrass	1.3c	0.9b	0.8b	65b	50b	60b
Crested wheatgrass	0.3c	0.2c	0.6b	29c	14c	32c
Weed control treatments						
Summer fallow	3.3a	1.4a	1.2ab	70ab	60a	60a
Fall plow	3.2a	0.8b	0.8b	58b	44b	38b
Fall furrow	2.2b	1.5a	1.8a	85a	61a	74a
Check	0.8c	0.6b	0.8b	29c	24c	30b

[1]Species and treatment means of density and frequency are compared within year. Means followed by the same letter are not significantly different at the 0.05 probability level as determined by Duncan's Multiple Range Test.

Table 4. Yield (lb/acre) of seeded and native species on upper and lower sites in 1970 and 1971. Seeded in fall, 1968.

Species	1970 Upper	1970 Lower	1971 Upper	1971 Lower
Pubescent wheatgrass	5784ax[1]	2992ay	4227ax	3118ay
Intermediate wheatgrass	3680bx	3248ay	3973ax	2245by
Regar bromegrass	1424cx	1784bx	408bx	1720cy
Tall fescue	40dx	1336by	40cx	692dy
Slender wheatgrass	3112b	–	1213b	–
Native sedge		1879		2286
Native slender wheatgrass		2000		3230

[1]Year means are compared among species and between sites. Means followed by the same letter (*a* through *d*) in vertical sequence or by the same letter (*x* or *y*) in horizontal sequence are not significantly different at the 0.05 probability level as determined by Duncan's Multiple Range Test.

Stand Productivity

Production in 1970 and 1971 on the 1968 seeding varied with site, year, and species (Table 4). Precipitation was 12.6 and 23.4 inches during these years on both sites. On the upper site in 1970, pubescent wheatgrass was the most productive species, followed by intermediate and slender wheatgrasses, bromegrass, and fescue. In 1971, pubescent and intermediate wheatgrasses produced similarly and significantly more than other species.

On the lower site in 1970, the wheatgrasses produced similarly and significantly more than did bromegrass or fescue. In 1971, pubescent wheatgrass produced most, followed by intermediate wheatgrass, bromegrass, and fescue.

Pubescent and intermediate wheatgrasses produced more on the upper site than on the lower site in both years.

[1]Personal communication. Harold L. Harris, Soil Conservation Service, Aberdeen, Idaho.

Stands were mostly full, and most environmental factors were similar. However, depth to water table varied considerably. Minimal depths were similar. However, by July, 1970 and 1971, the water table averaged 5 ft on the upper site and 8 ft on the lower site. By August of both years, the water table on the upper site still was 5 ft. On the lower site, the water table was 15 ft in 1970 and 12 ft in 1971. On the upper site, capillary rise above a 5 ft water table could increase the amount of soil moisture available to plants, and additional moisture would explain the high productivity. On the deeply gullied lower site, the water table and capillary fringe were below root depth after June in most years, and the productive potential was that of a dryland environment.

Production of bromegrass and fescue was generally higher on the lower site than on the upper site (Table 4). This is directly related to the difficulty of obtaining a full seedling stand of these species and maintaining a productive stand with intense competition from cheatgrass and poverty weed. Had full stands been obtained on the upper site, production probably would have been greater than on the lower site because of the water table effect.

Herbage yields were also determined in 1971 for species seeded in 1969 on the lower site. Intermediate wheatgrass in solid stands (2,150 lb/acre) and pubescent wheatgrass (2,300 lb/acre) did not differ significantly. Bromegrass (1,421 lb/acre) and intermediate wheatgrass in alternate rows with sainfoin or alfalfa (1,454 lb/acre) produced less, and fescue (614 lb/acre) least.

Plots of native slender wheatgrass and sedge were not included in the experimental design because stands were too scattered. However, production data are included in Table 4 for comparative purposes. In 1970, native slender wheatgrass produced less than did the seeded wheatgrasses but more than did bromegrass or fescue. Sedge production equalled or surpassed that of bromegrass and fescue in both years. In the wet year of 1971 production by slender wheatgrass (3,230 lb/acre) was similar to pubescent wheatgrass, and about 1,000 lb/acre greater than intermediate wheatgrass.

Management Implications

Conversion of depleted mountain meadows to productive stands of seeded species will require 1 year non-use during the fallow period and 1 or 2 years non-use for establishment. Fencing for establishment and future management may be the only practical means of livestock control.

Large improved meadows should be used for livestock and wildlife separately from surrounding dryland range. Deferment of grazing until after sage grouse occupancy would be a logical management approach. However, we need more research to determine the effects of grazing systems on the habitat and on sage grouse response.

Fencing and use of small improved meadows for livestock production would be impractical due to excessive stock moving and the few AUM's of forage available. These areas may justifiably be managed for wildlife, particularly sage grouse, although livestock water should be provided. Complete protection from livestock is undesirable. Seeded grasses can stagnate or become aggressive and crowd out wildlife food plants. Also, Oakleaf (1971) found that meadows with dense vegetation were not utilized by sage grouse. Livestock could be used to open the grass stand prior to sage grouse occupancy. However, forb palatability may dictate development of fenced areas within improved meadows seeded only to forbs. Seeded grasses would protect the site, livestock could utilize the grass to open the stand, and the unused forbs would be available to wildlife. This is intensive management, but perhaps it is needed to reestablish, maintain, or increase wildlife populations.

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